SUBHARMONIC MIXER WITH PLANAR SCHOTTKY DIODES IN A NOVEL SPLIT-BLOCK AT 200-240 GHz

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ABSTRACT

A broadband subharmonic mixer utilizing a planar antiparallel Schottky barrier diode pair has been developed for 220 GHz. The mixer is based on a novel split-waveguide block design consisting of only two central pieces and two tuner drivers which provide series and parallel tuning elements at both the local oscillator and signal frequency. The single sideband noise temperature is just below 2000 K from 210-235 GHz when an IF of 1.5 GHz is used. The conversion loss is 9.5-10 dB. A fixed-tuned useable IF bandwidth of more than 10 GHz was achieved with the new block design.

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SUMMARY

Subharmonic mixers utilizing an antiparallel Schottky barrier diode pair are of great interest for Earth remote sensing applications at short millimeter and submillimeter wavelengths because of their requirement for an LO frequency at one-half the signal frequency, simple RF diplexing and inherent LO noise suppression. The principle of the subharmonic mixer is described in [1, 2] and an accurate analysis is presented in [3]. Subharmonically pumped mixers have been successfully demonstrated at millimeter wavelengths with whisker contacted diodes, e.g. [4], and recently with planar diodes, e.g. [5]. Main disadvantages of the subharmonic mixers at millimeter and shorter wavelengths have been the difficulty of contacting the antiparallel diode pair with whiskers and also the difficulty of constructing the necessary waveguide mount containing waveguides of two different sizes and several impedance tuners. Now, planar chips containing a pair of antiparallel Schottky barrier diodes are available from the University of Virginia [6]. In this work, a simple split-waveguide mount design [7] has been successfully applied to a 200-240 GHz subharmonically pumped planar Schottky diode mixer.

The new mount, shown in Fig. 1, consists of only two pieces, block halves, which are mirror images of each other. The mount provides parallel and series impedance tuning with two sliding backshorts at both the input and output frequencies while utilizing E-plane arms to provide an in-line waveguide input and output. Its fabrication is much easier than that of a traditional multifrequency waveguide mount. Waveguide losses are minimized by a very compact design with very short input and output waveguides. The mount is well suited for planar diodes used with a microstrip RF filter.

The mixer SSB noise performance and conversion loss were measured at 195-235 GHz with an IF of 1.5 GHz. The SSB mixer noise temperature is about 2000 K from 210-235 GHz, as shown in Fig.2 a). The SSB mixer noise temperature stays below 3500 K at IF frequencies from 1 to 12 GHz when the LO frequency, is 110 GHz (the nominal design center frequency). The corresponding conversion loss is 9.5 - 10 dB (Fig. 2 b). The best SSB mixer noise temperature obtained earlier in this frequency range is 1715 K with an associated conversion loss of 8.7 dB [5]. The wide, flat frequency response of this mixer represents the state-of-the-art.

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REFERENCES

[1] M.V. Schneider and W.W. Snell Jr., “Harmonically pumped stripline-downconverter", IEEE Trans. Microwave Theory and Tech., vol. MTT-23, no. 3, pp. 271-275, March 1975.

[2] M. Cohn, J.E. Degenford, and B.A. Newman, "Harmonic mixing with an antiparallel diode pair”, IEEE Trans. Microwave Theory and Tech., vol. MTT-23, no. 8, pp. 667-673, Aug. 1975.

[3] A.R. Kerr, “Noise and loss in balanced and subharmonically pumped mixers: Part I - Theory”, and “Part II - Experiment”, IEEE Trans. Microwave Theory and Tech., vol. MTT-27, no. 12, pp. 938-950, Dec. 1979.

[4] T.F. McMaster, M.V. Schneider, and W.W. Snell, Jr., “Millimeter wave receivers with subharmonic pump”, IEEE Trans. Microwave Theory and Tech., vol. MTT-24, no. 12, pp. 948-952, Dec. 1976.

[5] P.H. Siegel, R.J. Dengler, 1. Mehdi, W.L. Bishop, and T.W. Crowe, “A 200 GHz planar diode subharmonically pumped waveguide mixer with state-of-the-art performance”, 1992 IEEE MTT-S International Microwave Symposium Digest, June 1992, pp. 595-598.

[6] W.L. Bishop, K. McKinney, R.J. Mattauch, T.W. Crowe, and G. Green, “ A novel whiskerless Schottky diode for millimeter and submillimeter wave application”, 1987 IEEE MTT-S International Microwave Symposium Digest, June 1987, pp. 607-610.

[7] A.V. Räisänen, D. Choudhury, R.J. Dengler, J.E. Oswald, and P.H. Siegel, “A novel split-waveguide mount design for mm and submm wave frequency multipliers and harmonic mixers”, IEEE Microwave and Guided Wave Letters, vol. 3, no. 10, Oct. 1993.

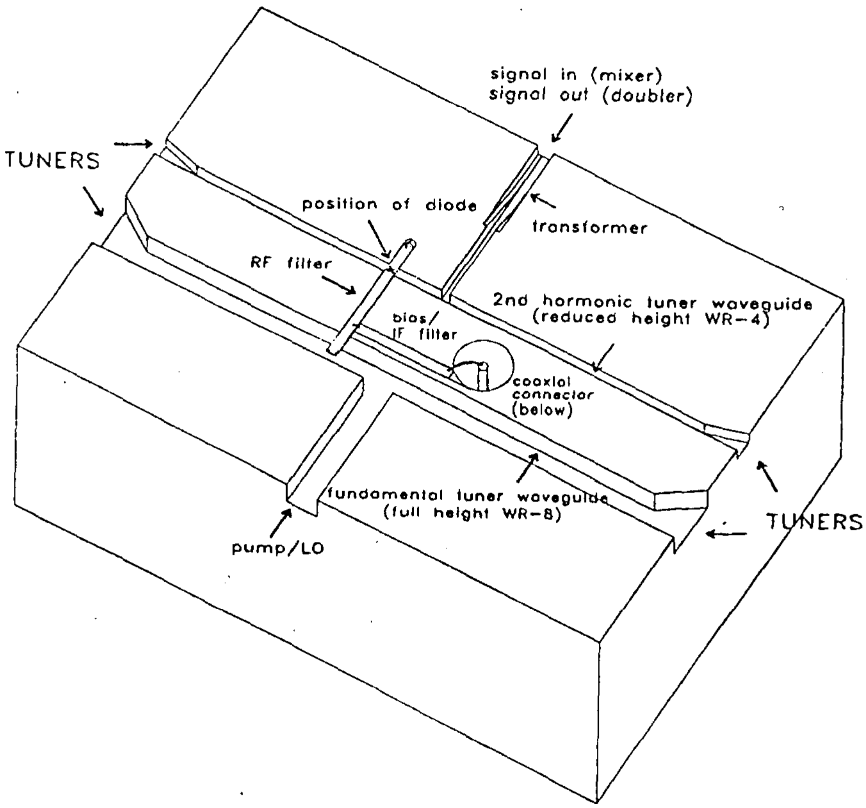

Figure 1. Schematic drawing showing one half of the 220 GHz subharmonic mixer mount.

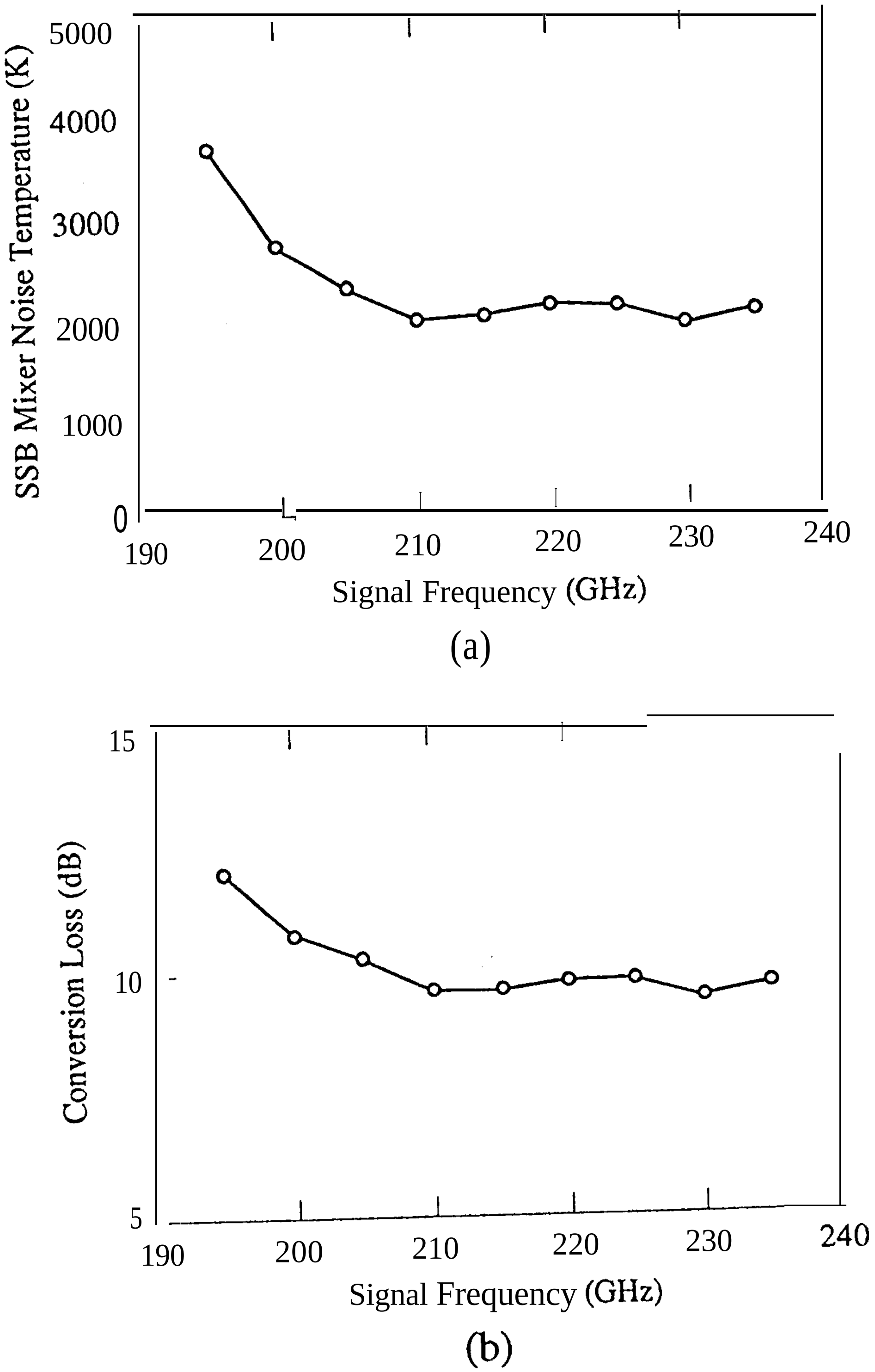

Figure 2. a) SSB mixer noise temperature, and b) conversion loss.